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Biochemical, Microbial Stability and Sensory Evaluation of Osmotically Dehydrated Kinnow Peel Candy and Peel Powder

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Abstract: ***Kinnow peel is a rich source of ascorbic acid, pectin, naringin and limonin that goes waste during processing and utilization of kinnow into various products. Kinnow peel candy and peel powder prepared by osmotic dehydration retain color, aroma, taste and nutritional components of the peel for longer duration. In this present investigation, products were packed in four different packaging materials (HDPE, LDPE, laminate bag and glass jar) and stored under ambient (37-44°C, relative humidity 56%) and refrigerated conditions (4-6°C, relative humidity 95%) for 60 days to study the effect of storage conditions and packaging material. The acceptability of the products was tested through biochemical, microbiological analysis and sensory evaluation of the peel candy and powder at regular intervals (0, 30 and 60 days) during storage. All packaged materials were capable of maintaining the microbial load below the limits. The candy packed in HDPE bag and peel powder packed in laminate bag was overall acceptable and microbiologically stable till storage of 60 days under both (ambient and refrigerated) conditions.***

Keywords: Kinnow peel candy, osmotic dehydrated peel powder, microbial load, biochemical characteristics and sensory evaluation

1. Introduction

Kinnow is a first generation hybrid of “King” and “Willow leaf” mandarins (citrus nobilis and citrus delicosa [17]. Kinnow is a variety of citrus cultivated extensively in North India. It has become an important variety in the state of Punjab, occupying a major part of the area under cultivation for fruit crops. Punjab is a leading producer of kinnow and accounts for 29% of the production in the country, with a productivity of 21.4 MT/hectares, which is the highest in the country [6]. Kinnow has many industrial and medicinal uses, has an attractive color, distinctive flavor and is a rich source of vitamin „C“, vitamin „B“, β-carotene, calcium and phosphorous [34]. It is rich in pectin, cellulose and hemicelluloses. On an average, kinnow peel contains 22.45% total solids, 12.50°Bx TSS, 1.38% acidity, 41.57 mg/100g ascorbic acid, 6.23% total sugars, 5.99% reducing sugars, 0.67% ash, 13.65 mg/100g carotenoids, 7.43 mg/100g β-carotene, 1.85% pectin and 0.77% fat [2]. It also contains 0.42 mg/g approximately naringin and 4.69 mg/g of approximately limonin [26].

The peel of the fruit, which is generally considered a waste is more nutritious than juice and can be processed into candies, that may be further used in the baking industry in the preparation of cakes, cookies, steamed puddings, sweet breads, mixed candied fruits and in marmalades. Candy is a sweet food prepared from fruits or vegetables by impregnating them with sugar syrup followed by draining of excessive syrup and then drying the product to a shelf stable state. Fruits and vegetables like apples, ginger, mangoes, guava, carrot and citrus peels have been used to prepare candies [24].

Osmotic dehydration is one of most effective treatment and food preservation technique in the processing of dehydrated foods, since it presents some benefits such as reducing the damage of heat to the flavor, color, inhibiting the browning of enzymes and decreases the energy costs [3 and 20]. It leads to attractive products that are ready to eat. Being a simple process, it facilitates processing of tropical fruits and vegetables such as banana, sapota, pineapple, mango, and leafy vegetables etc. with retention of initial fruit and vegetables characteristics viz., colour, aroma and nutritional compounds.

The variation in bio and physico-chemical composition affects the structural, sensory and textural properties of fruits [28]. Different biochemical constituents such as pectin helps in glycemic control, cancer prevention and control of mineral balance [7and21]. Likewise limonene is effective for cancer prevention [10]. Antioxidants and vitamin C can protect LDL cholesterol from oxidation, to help reduce the incidence of heart disease and can also block the formation of carcinogenic nitrosamines in the body [22]. The citrus flavonoids (Hesperidin and Naringin) have been found to have antioxidant, anticancer, antiviral and anti-inflammatory activities, etc. [8]. The effect of sucrose with fructose on the physico-chemical composition and sensory characteristics of kinnow candy during storage [1]. Moisture, acidity and ascorbic acid decreased, while total soluble solids, reducing and total sugars and limonin increased, with no change in ash content of the candies, during four months of storage.

In addition to health aspects, consumers expect food safety. The importance of the microbial aspects during the process appears to be fundamental if osmotic dehydration process is

to be implemented. The quality of dried foods is dependent on changes occurring during processing and storage. It is well established that surface microbial growth is the main cause of spoilage for many ambient and refrigerated food products. The reduction of water activity of fresh-cut fruits by osmo dehydration might inhibit the growth of microorganisms [4]. Practices used during the preparation, handling, cleaning, sorting and grading, packaging and storing are some of the factors, which increase the risk of acquiring microbes. Careful handling and process hygiene is important to avoid the microbial contamination.

Due to increased consumer awareness for healthier eating habits, this research project was developed to study biochemical, microbiological and sensorial characteristics of kinnow peel candy and peel powder.

2. Materials and Methods

Procurement of the sample
Osmotic dehydrated kinnow peel candy and peel powder were procured from Department of Food Processing and Engineering, Punjab Agricultural University, Ludhiana, India.

Packaging and storage
The osmo-convective dehydrated kinnow peel slices (candy and peel powder) developed under the optimized conditions were packed in different packaging materials (HDPE, LDPE, laminate bag and glass jar) and kept under different storage conditions (ambient and refrigerated) to ascertain their shelf life and keeping quality. The samples were analyzed at regular intervals for biochemical, microbiological analysis and sensory evaluation.

Biochemical analysis
Ascorbic acid content was determined based on the 2, 6-dichlorophenolindophenol titration method. The dye, which is blue in alkaline solution, is reduced by ascorbic acid to a pink form. Flavonoid (naringin) content was determined by spectrophotometer method by Davis [11]. Limonin content was estimated from the chloroform extract of sample by spectrophotometric method of Vaks and Lifshitz [38]. Pectin was extracted by a method given by Rao and Miani [29].

Microbiological analysis
The microbiological analysis of stored products (peel candy and powder) was conducted by Total plate count, yeast and molds count, *Escherichia coli*, *Staphylococcus aureus* and *Salmonella* using their respective culture media. Ten grams of each sample was aseptically transferred to 90 ml of 1% sterile peptone water into sterile flask while for *Salmonella* 25 g of sample was aseptically transferred to 75 ml of 1% buffered peptone water. The samples were homogenized by blending for 2 min at vortex and incubated at 35-37°C for 2 hours. Total plate count was determined by incubating the samples for 72 hours at 30°C. The yeast and molds were determined by incubating the samples on potato dextrose agar for 3 to 5 days at 22°C. *Escherichia coli* were enumerated on Eosin methylene blue agar media by incubating the plates at 35-37°C for 24-48 hours. *Salmonella* was enumerated by incubating the samples on Salmonella shigella agar at 35-37°C for 24-48 hours. Staphylococcus aureus was enumerated by incubating the samples on Mannitol salt agar at 35-37°C for 24-48 hours. All culture media were procured from Hi-Media Laboratories. Experiment was conducted in triplicate and the count was expressed as colony forming units (cfu) per gram of the sample. The average colony count was multiplied by the dilution factor to find the number of cells per gram of the sample.

Sensory evaluation
Organoleptic quality of developed products was conducted on a 9-point hedonic scale [32]. Semi trained panel of 9 judges was selected for evaluating the samples in terms of taste, appearance, color, texture, aroma, mouth feel and overall acceptability. Overall acceptability was evaluated as an average of taste, appearance, color, texture, aroma and mouth feel.

3. Result and Discussion

Biochemical analysis of fresh kinnow peel
Kinnow peel is rich source of ascorbic acid (47.52 mg/100g), pectin (18.56%), naringin (358µg/g) and limonin (60.75µg/g). The results were in concordance with the finding of Maan *et al.*, who also reported 40.7 mg/100g ascorbic acid [22] and 374 µg naringin in fresh kinnow peel. Aggarwal and Michael reported 459ppm of limonin and 40.7 mg/100g ascorbic acid in kinnow peel [1]. Premi *et al*. [26] reported that kinnow peel contains 0.42 mg/g approximately naringin and 4.69 mg/g of limonin, whereas in a report submitted by Punjab Horticultural Postharvest Technology Centre, Punjab Agricultural University, Ludhiana, limonin content in peel varied from 67.9-80.4 µg/g [5]. The yield of pectin was in accordance with the result reported by Singh and Dhillon [33], who extracted pectin with 0.05 N HCl and obtained 14.80% (w/w) yield of pectin. Similarly, other workers [29 and 35] have also reported 18.3-20% of pectin yield in kinnow peel.

Effect of storage conditions on Ascorbic acid
Ascorbic acid content decreased with storage time in all the packaging materials, stored under ambient and refrigerated conditions (Fig. 3.1). The mean values of ascorbic acid decreased from 42.2 mg/100g to 18.4, 14.4, 17.1 and 14.4 mg/100g in candy packed in HDPE, LDPE bag, laminate bags and glass jars stored, under ambient conditions respectively. Minimum percent decrease was found in HDPE bag (31.75%) followed by that in laminate bag (40.75%) stored under refrigerated conditions. Similarly in peel powder, the mean values of ascorbic acid decreased from 33 mg/100g to 15.7, 14.4 14.5 and 13.1 mg/100g in product packed in HDPE, LDPE, laminate bags and glass jars stored under ambient conditions respectively. Minimum percent decrease was observed in laminate bag (40%) followed by LDPE bag (44.24%) stored under refrigerated conditions. Packaging materials, storage conditions, interaction of packaging materials and storage conditions have significant effect till the storage period of 60 days in candy. Whereas in peel powder, packaging materials and storage conditions did not have a significant effect till storage of 60 days at 5 % level of significance. The loss in ascorbic acid content might be due to the effect of light and prevailing high temperature conditions under ambient

storage. The other factor for the degradation of ascorbic acid is the influence of temperature exerted at the time of processing. The results were in correlation with Khan et al. [19], who reported that the mean values of ascorbic acid content significantly decreased from 54.82 to 30.08 mg/100g during storage. Similarly Aggarwal and Michael [1], observed a significant loss of ascorbic acid from 11.4 to 3.3 mg/100g in kinnow candy during the storage of four months. Kaur *et al*. [18] reported maximum loss of ascorbic acid in LDPE bag during storage.

Effect of storage conditions on Pectin

A decreasing trend of pectin was observed for the stored products i.e. candy and peel powder (Fig. 3.2). The minimum yield of pectin (6.63%) in candy was recorded in glass jar while, in peel powder the minimum yield of pectin (2.83%) was recorded in LDPE bag stored under ambient conditions. The maximum pectin yield (7.92%) was observed in LDPE bag followed by HDPE bag (7.54%) in candy stored under refrigerated conditions, whereas in peel powder, laminate bag stored under refrigerated conditions had a maximum yield of pectin (3.2%). Pectin plays an important role for sugar osmo-dried products such as preservation and holding sugars in the finished product. Thus retention of the sufficient quantity of pectin is a desirable character. The decrease in pectin yield might be due to the pectin degradation caused by the depolymerisation of galactouronan chain of pectin also known as β-elimination during the storage. The significant effect of packaging material was observed after 60 days of storage in candy, whereas in peel powder, packaging material as well as storage conditions were significant till storage period of 60 days. At the same time an interaction of packaging material and storage conditions was observed to be non-significant till storage period of 60 days in both candy and peel powder. The results were in concordance with Tripathi *et al.* [37], who reported same type of decreasing behavior, but to a lesser extent in amla preserves from variety Banarsi. Similarly, Mehta *et al.* [23] reported significant loss of pectin from 74 to 44% during storage in galgal peel candy.

Effect of storage conditions on naringin

The naringin content decreased with gradual passage of storage time, in peel candy and powder (Fig 3.3). The minimum content of naringin 146µg/g in candy and 148µg/g in peel powder was observed in glass jar stored under ambient conditions. With respect to packaging materials, the maximum naringin content in candy was observed in HDPE bag, whereas in peel powder the maximum naringin content was observed in laminate bag stored under refrigerated conditions. The statistically analyzed data did not show significant effect of packaging materials and storage conditions till the storage period of 30 days, but significant effect of packaging materials was observed after storage period of 60 days for candy and peel powder. An interaction of packaging materials and storage conditions was not significant in peel candy and powder.

Effect of storage conditions on limonin

The limonin content was observed to be consistent till the storage period of 30 days under ambient and refrigerated conditions, but decreased as the storage period progresses for the stored product (Fig 3.4). The minimum limonin content (29.9µg/g) in candy was recorded in laminate bag. Minimum limonin content 23.5µg/g was recorded in LDPE bag, stored under ambient conditions in peel powder. The maximum limonin content in candy and peel powder was observed in HDPE bag, stored under refrigerated conditions. The statistically analyzed data did not show significant effect of packaging material and storage conditions till the storage period of 60 days for peel candy and powder. An interaction of packaging materials and storage conditions was not significant in peel candy and powder. The results were in harmony with the finding of Wuttipalakorn et al. [40], who reported decline in limonin contents after drying in lime powder.

Microbiological analysis

Osmotic dried fruits and vegetables have low moisture content and low water activity. They are hard, firm and resistant to microbial deterioration. Microbial load plays a very important role in determination of the length of storage till which the product remains consumable [39]. Temperature, oxygen and moisture content are the most important factors that influence the type of microbial growth and spoilage of food during storage.

Total plate count

Total plate count is a useful measure for process control. Table 1-2 depicts the change in the total plate count during storage of peel candy and powder, packed in different packaging material, stored under ambient and refrigerated conditions. It was observed that, total plate count increased by five fold in peel candy and by four fold in powder till the storage of 60 days. It is clearly evident from the Table 1-2 that, maximum total plate count was observed in glass jar followed LDPE bag in peel candy and powder stored under ambient conditions. According to microbiological recommended criteria for dried fruits, the associated total plate count should be below 10^4cfu/g (ICMSF 2011). Thus total plate count of peel candy and powder was within the limits under ambient and refrigerated conditions. The product was microbiological stable in all the packaging material till the storage period of 60 days under ambient as well as refrigerated conditions. During storage, candy packed in HDPE bag and peel powder packed in laminate bag had least total plate count. Increase in total plate count could be due to favorable environment factors like temperature, relative humidity, storage conditions and food factors like pH, water activity, moisture content and nutrients present [16]. The results were in concordance with the finding of Hasanuzzaman et al. [15], who reported a bacterial count of 1×10^1, 3×10^1 and 7×10^1 cfu/gm in candy with 40%, 50% and 60% sugar solution respectively during storage.

Yeast and Molds

It was observed that, yeast and molds count increased during ambient and refrigerated storage. It is evident from the Table 3 that the maximum yeast and molds count in candy was observed in glass jar stored under ambient conditions till the storage of 60 days. Whereas, in peel powder the maximum yeast and molds count was observed in LDPE bag followed glass jar stored under ambient conditions (Table 4). The least yeast and molds count in candy was observed in HDPE

bag. While in peel powder, the least count was observed in laminate bag stored under refrigerated conditions. According to microbiological recommended criteria for dried fruits, the associated yeast and molds count should be below 10^3cfu/g, as per specifications by Food Administration Manual [6]. All packaging materials were capable of maintaining the microbial load below 10^3cfu/g throughout the storage. These results were in line with the finding of Moreno *et al.* [25] who reported a minor growth of yeasts and molds in ohmic heating/osmotic dehydration treated apples during storage. All the samples had yeast and molds count within permissible limits during storage at 5 and 10°C. Other researcher such as Castelló *et al* [9] also reported an increase in yeast and molds count in apple slices during storage.

Detection of *Escherichia coli, Staphylococcus aureus and Salmonella*

Escherichia coli, Staphylococcus aureus and Salmonella were not detected in peel candy and powder during storage. The results were in correlation with the finding of Hasanuzzaman *et al* [15] who reported *S. aureus* counts on candy with 40%, 50% and 60% sugar solution was nil at the initial and till 6 months storage.

Sensory evaluation

Sensory evaluation was done on 9 point hedonic scale, based on consumer acceptability for peel candy and powder. The products were stored in different packaging materials for a period of 60 days and were evaluated organoleptically for taste, appearance, color, texture, aroma, mouth feel and overall acceptability, with a storage interval of 30 days.

Taste

The mean organoleptic scores for taste are graphically represented in Fig. 3.5. The mean score for taste decreased from 8 to 7.4, 7.3, 7.4 and 7.3 in HDPE, LDPE, laminate bag and glass jar stored under ambient conditions during storage of 60 days. While under refrigerated conditions mean score for candy taste decreased from 8 to 7.6 in HDPE bag and 7.5 in LDPE, laminate bag and glass jar, till storage period of 60 days. Similarly in peel powder the initial average score rate for taste of the candy was 7.8 which gradually decreased to 6.5, 6.6, 7.0 and 6.6 in HDPE, LDPE, laminate bag and glass jar respectively during storage period of 60 days under ambient conditions. Under refrigerated condition, the average score for taste gradually reduced to 7.2, 7.0, 7.4 and 7.1 in HDPE, LDPE, laminate bag and glass jar respectively. Better retention of taste was observed in HDPE bag and laminate bag in peel candy and powder respectively, stored under refrigerated conditions. The statistically analyzed data showed that packaging materials and interaction of packaging materials and storage conditions did not have a significant effect on sensory score, while storage conditions were observed to be significant till storage period of 60 days at 5% level of significance. These results were in harmony with the observation of Dermesonlouoglou *et al* [12], who reported 54.55% decrease in taste scores of osmo-dehydrofrozen tomatoes, during 12 months storage.

Appearance

Mean score for appearance of the peel candy and powder declined with the advancement of the storage period (Fig. 3.6). Maximum mean score for appearance (8.6) in candy was observed in HDPE bag stored under refrigerated conditions. Whereas in peel powder, the maximum mean score for appearance (8.0) was observed in laminate bag followed by 7.6 score in HDPE bag and glass jar stored under refrigerated conditions till the storage of 60 days. The statistically analyzed data showed that packaging material, interaction of packaging material and storage conditions did not have a significant effect on sensory score while storage conditions were observed to be significant till storage period of 60 days at 5% level of significance. Similar findings were reported by Gupta [14] in ber candy and Priyadarshini [27] in apple candy.

Color

Osmotic drying had a protective effect upon the color of fully dried fruits [13]. The mean score for color decreased from 8.7 to 8.4, 8.3, 8.2 and 8.2 in HDPE bag, LDPE, laminate bag and glass jar in candy, stored under ambient conditions (Fig. 3.7). For packaging materials, the maximum mean score (8.6) was recorded in HDPE bag while minimum mean score (8.2) was recorded in laminate bag and glass jar. Similarly in peel powder, the average mean score decreased from 8.6 to 6.5, 6.6, 7 and 6.6 in HDPE bag, LDPE, laminate bag and glass jar respectively, stored under ambient conditions till storage of 60 days (Fig. 3.7). The maximum mean score (7.6) was observed in peel powder packed in laminate bag followed by mean score (7.5) in LDPE bag, stored under refrigerated conditions. The color of peel candy and powder was attractive under refrigerated conditions during storage. The statistically analyzed data revealed that packaging material, interaction of packaging material and storage conditions did not have a significant effect on sensory score. While storage conditions had a significant effect till storage period of 60 days at 5% level of significance. The results were in line with observation of Durrani *et al* [13], who reported mean score of color decreased from 8 to 6.8 in LDPE bag and glass jar during storage of six months in honey based carrot candy. Similarly, Shamrez *et al* [31] reported mean score of citron peel candy ranged 8.0 -1.0 during storage of 180 days.

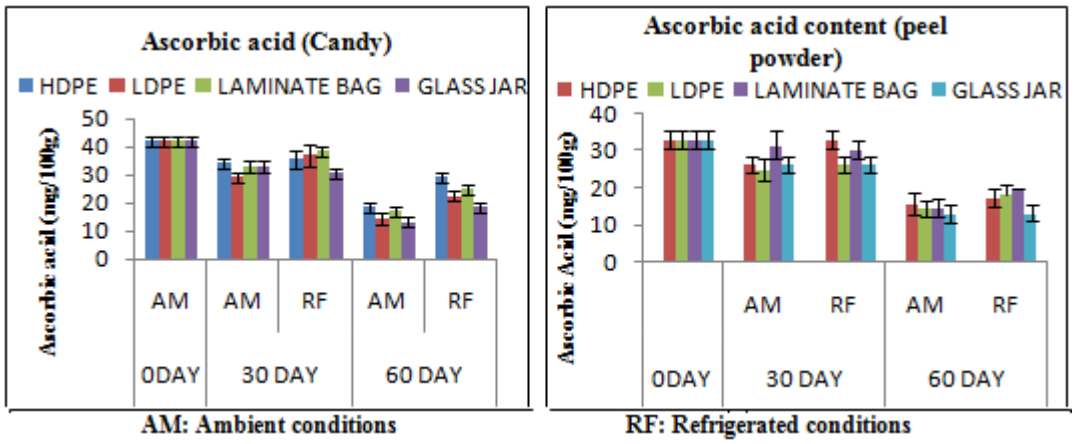

Figure 3.1: Effect of storage on ascorbic acid in candy and peel powder

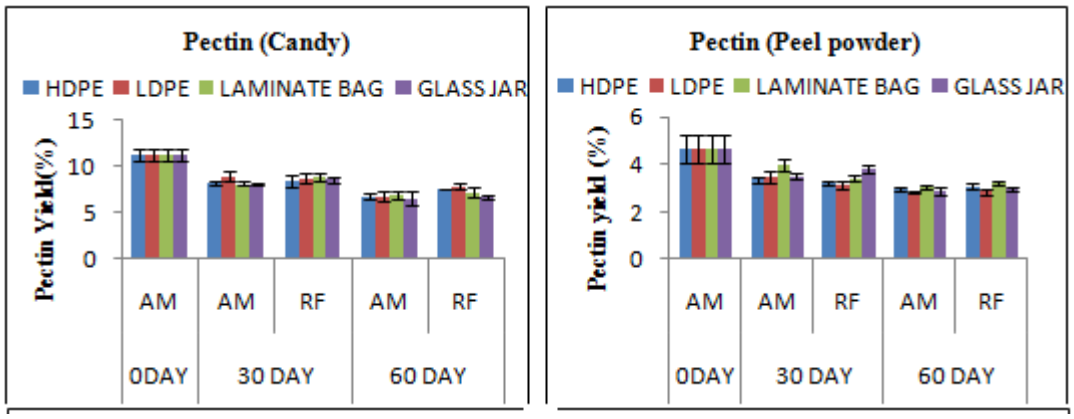

Figure 3.2: Effect of storage on pectin in candy and peel powder

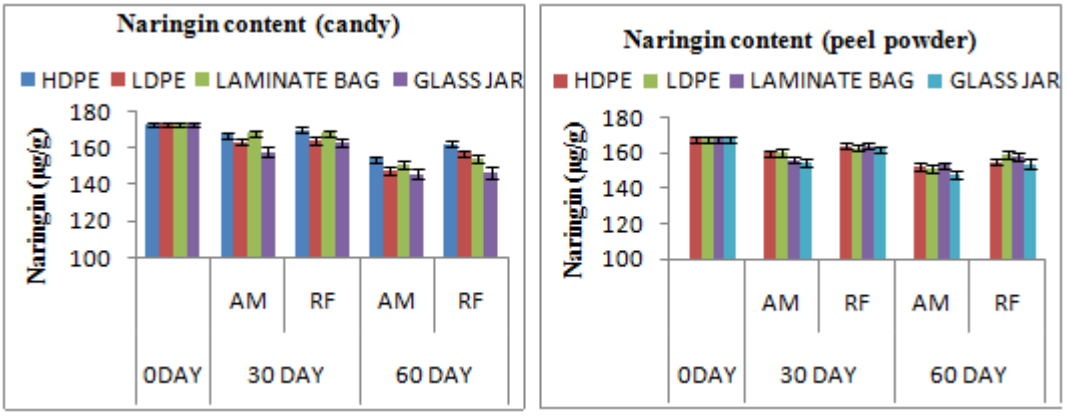

Figure 3.3: Effect of storage on naringin in candy and peel powder

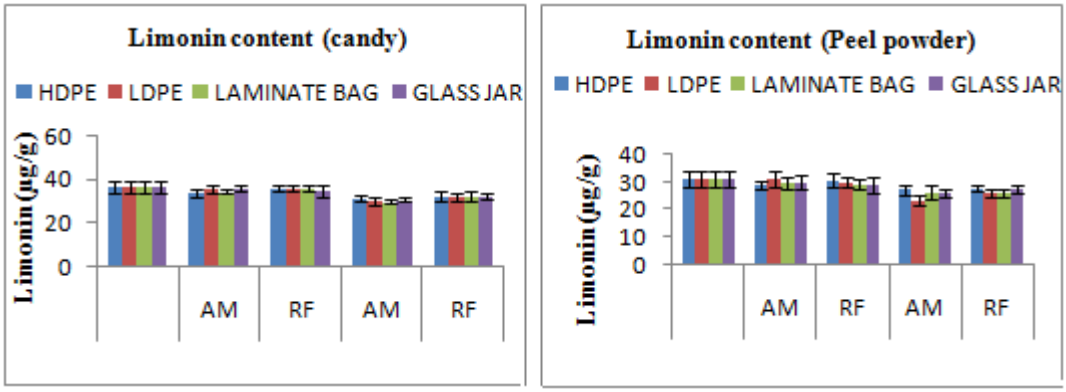

Figure 3.4: Effect of storage on limonin in candy and peel powder

Table 1: Enumeration of Total plate count in candy during storage

Total plate count ($\times 10^3$cfu/g) in candy						Microbiological limits (cfu/g) for dried fruits (ICMSF 2011)
No. of Storage Days	0	30		60		
Packaging Material		Ambient conditions	Refrigerated conditions	Ambient conditions	Refrigerated conditions	
HDPE BAG	1.3±0.8	2.3±0.9	1.3±0.4	5.3±0.4	1.3±0.4	
LDPE BAG	1.3±0.8	3.3±0.4	1.6±0.8	6.3±1.6	2±0.4	
LAMINATE BAG	1.3±0.8	2.6±1.2	1.3±0.4	5.6±1.2	1.6±0.8	$<10^4$
GLASS JAR	1.3±0.8	3.3±0.4	1.6±0.4	6.6±1.2	2.3±0.4	
CD (5%)		A=0.72 B=NS AB=NS		A=1.02 B=NS AB=NS		

Data represent mean±SD of triplicates (n=3) ND: Not Detected
A: Packaging material B: Storage conditions

Table 2: Enumeration of Total plate count in peel powder during storage

Total plate Count ($\times 10^3$cfu/g) in peel powder						Microbiological limits (cfu/g) for dried fruits (ICMSF 2011)
No. of Storage Days	0	30		60		
Packaging Material		Ambient conditions	Refrigerated conditions	Ambient conditions	Refrigerated conditions	
HDPE BAG	1.3±0.4	2.3±0.9	1.3±0.4	4.0±1.6	2.0±0.4	
LDPE BAG	1.3±0.4	2.6±0.4	1.6±0.8	4.6±0.8	2.3±0.8	
LAMINATE BAG	1.3±0.4	1.6±0.4	1.3±0.4	3.6±0.4	1.6±0.4	$<10^4$
GLASS JAR	1.3±0.4	2.6±0.9	1.6±1.2	5.3±1.2	2.6±0.8	
CD (5%)		A=0.82 B=NS AB=NS		A=0.99 B=NS AB=NS		

Data represent mean±SD of triplicates (n=3) ND: Not Detected
A: Packaging material B: Storage conditions

Table 3: Enumeration of Yeast and Molds in candy during storage

Yeast and Molds count ($\times 10^2$cfu/g) in candy						Microbiological limits (cfu/g) for dried fruits (Food Administration Manual 1995)
No. of Storage Days	0	30		60		
Packaging Material		Ambient condition	Refrigerated condition	Ambient condition	Refrigerated condition	
HDPE BAG	1.0±0.4	1.0±0.8	1.0±0.9	2.6±0.9	1.0±0.4	
LDPE BAG	1.0±0.4	1.3±0.4	1.3±0.4	3.0±0.8	1.6±0.8	
LAMINATE BAG	1.0±0.4	1.3±0.4	1.3±0.4	2.9±0.9	1.3±0.4	$<10^3$
GLASS JAR	1.0±0.4	2.0±0.4	1.6±0.9	4.3±0.4	2.0±0.8	
CD (5%)		A=NS B=NS AB=NS		A=0.78 B=NS AB=NS		

Data represent mean±SD of triplicates (n=3) ND: Not Detected
A: Packaging material B: Storage conditions

Table 4: Enumeration of Yeast and Molds in peel pwder during storage

Yeast and Molds count ($\times 10^2$cfu/g) in peel powder						Microbiological limits (cfu/g)for dried fruits (Food Administration Manual 1995)
No. of Storage Days	0	30		60		
Packaging Material		Ambient condition	Refrigerated condition	Ambient condition	Refrigerated condition	
HDPE BAG	1.0±0.8	2.3±0.4	1.0±0.4	3.6±0.9	1.3±0.4	
LDPE BAG	1.0±0.8	3.3±0.4	1.0±0.4	5.3±0.4	1.0±0.4	
LAMINATE BAG	1.0±0.8	2.3±0.4	1.0±0.4	3.0±0.8	1.0±0.8	$<10^3$
GLASS JAR	1.0±0.8	1.6±0.4	1.0±0.8	4.3±1.2	1.3±0.9	
CD (5%)		A=0.55 B=NS AB=NS		A=0.86 B=NS AB=NS		

Data represent mean±SD of triplicates (n=3) ND: Not Detected
A: Packaging material B: Storage conditions

Aroma

The mean score for aroma decreased from 8.7 to 6.6, 6.4, 6.5 and 6.5 in HDPE bag, LDPE, laminate bag and glass jar in candy stored under ambient conditions (Fig. 3.8). For packaging materials, the maximum mean score (6.8) for candy was recorded in HDPE bag while minimum mean score (6.5) was recorded in laminate bag and glass jar. Similarly in peel powder, the average mean score for aroma decreased from 9 to 6.3 in all the packaging material stored under ambient conditions (Fig. 3.8). Maximum mean score

for aroma (6.7) in peel powder was observed in laminate bag stored under refrigerated conditions. The statistically analyzed data showed that packaging material, interaction of packaging material and storage conditions did not have a significant effect on aroma. While storage conditions had a significant effect till storage period of 60 days at 5% level of significance. Torres *et al* [36] also reported loss of aroma in osmo dehydrated mango during storage.

Overall acceptability

The sensory score to the response of the storage conditions and packaging material on overall acceptability is depicted in Fig. 3.9. The mean score for overall acceptability decreased from 8.3 to 7.5 in all packaging material stored under ambient conditions. The maximum mean score for candy was recorded in HDPE bag (7.9), stored under refrigerated conditions. The maximum mean score for peel powder was observed in laminate bag (7.3) stored under refrigerated conditions. The statistically analysis of data showed that packaging material, interaction of packaging material and storage conditions did not have a significant effect on sensory score. While storage conditions had a significant effect till storage period of 60 days at 5% level of significance. The observations were in line with the observation of Sabrina *et al* [30], who observed a decline in the overall acceptability of osmo dehydrated mango slices. Similarly, Shamrez *et al* [31] reported 27.11 to 87.14% decrease in overall acceptability of citron peel candy during storage of 180 days.

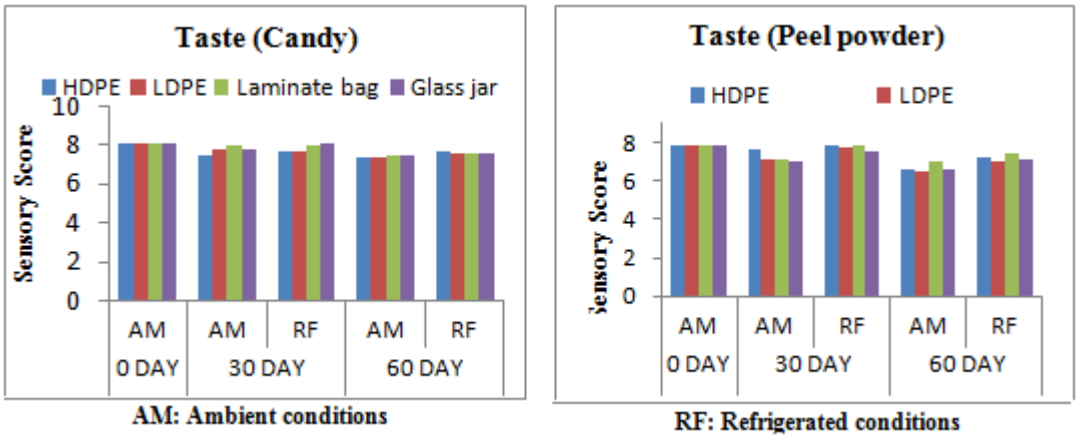

Figure 3.5: Taste of peel candy and powder during storage

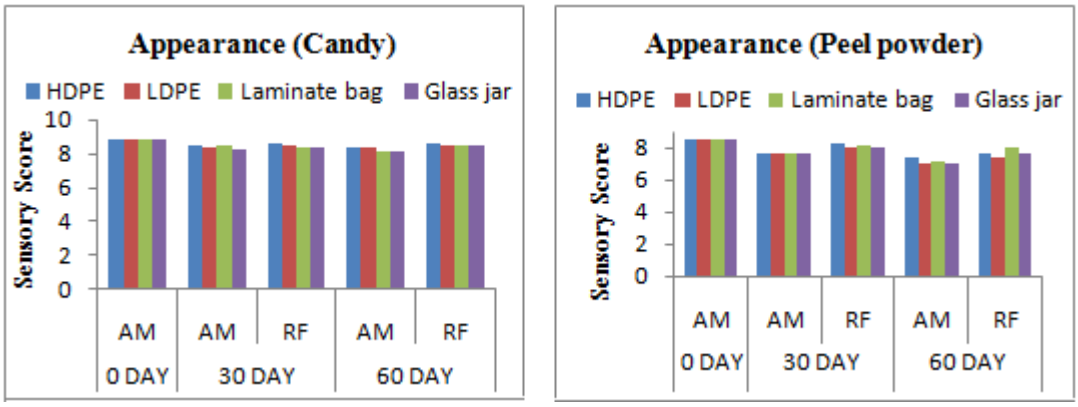

Figure 3.6: Appearance of peel candy and powder during storage

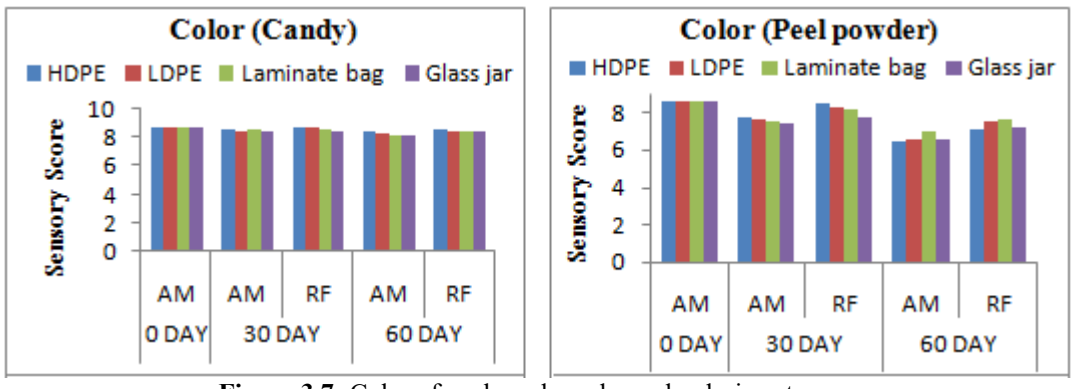

Figure 3.7: Color of peel candy and powder during storage

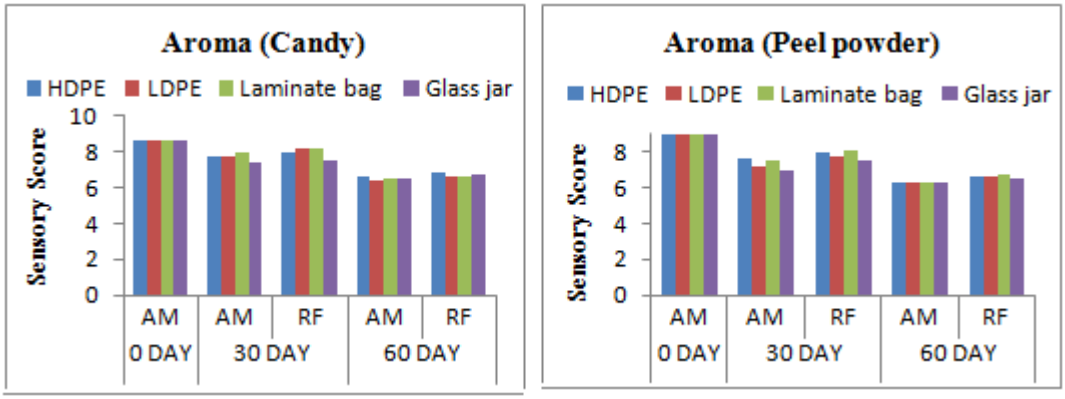

Figure 3.8: Aroma in peel candy and powder during storage

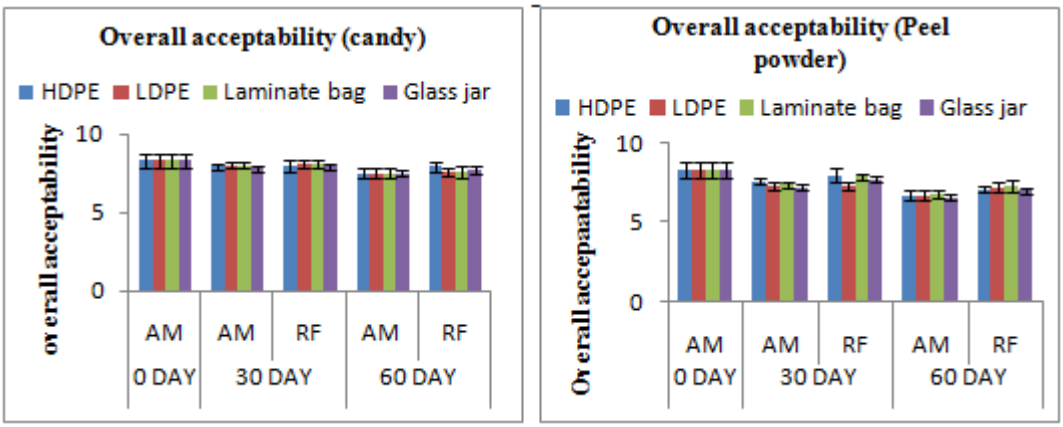

Figure 3.9: Overall acceptability of peel candy and powder during storage

4. Conclusion

Biochemical characteristics (ascorbic acid, pectin, naringin and limonin content) showed a decreasing trend with increase in storage period for peel candy and powder till the storage period of 60 days. Candy packed in HDPE bag stored under refrigerated conditions was overall acceptable till storage of 60 days. Whereas, in peel powder the laminate bag followed by HDPE bag had higher overall acceptability till storage of 60 days under refrigerated conditions. Microbiological analysis (total plate count, yeast and molds) showed increasing trend with increase in storage period. Total plate count increased by five fold in peel candy and by four fold in peel powder stored under ambient conditions. Yeast and molds increased by 4.3 fold in peel candy and by 5.3 fold in peel powder stored under ambient conditions. Although, according to microbiological recommended criteria for dried fruits, the total plate counts, yeast and molds count was within permissible limits during storage of 60 days under ambient and refrigerated conditions (ICMSF 2011 and Anonymous 1995). Osmotic dehydration had great influence on pathogenic micro-organism. Escherichia coli, Staphylococcus aureus and Salmonella were not detected in peel candy and powder during storage. Thus, the products were microbiological stable till storage of 60 days under ambient and refrigerated conditions. Among all the packaging materials, candy packed in HDPE bag followed by laminate bag was microbiological stable as compared to other packaged materials stored under ambient as well as refrigerated conditions till storage of 60 days. Peel powder packed in laminate bag was microbiological stable under refrigerated conditions till storage of 60 days. Thus candy packed in HDPE bag and peel powder packed in laminate bag were overall acceptable with high shelf life as compared to product packed in LDPE bag and glass jar.

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